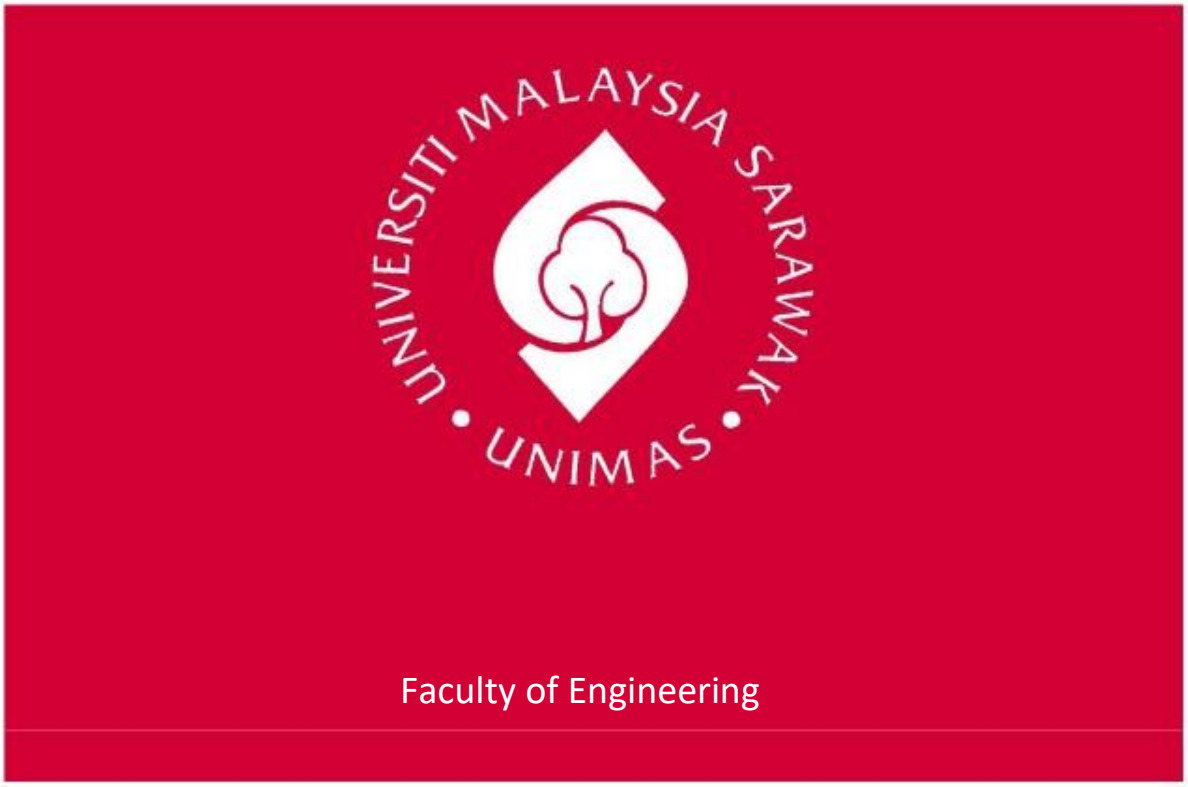

FABRICATION AND CHARACTERIZATION OF REDUCED GRAPHENE OXIDE BASED ON DSSC

Asyraf Ariffifuddin Bin Daud

Bachelor of Engineering (Hons)
in Electronics (Telecommunications)
2019

UNIVERSITI MALAYSIA SARAWAK

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FABRICATION AND CHARACTERIZATION OF REDUCED GRAPHENE OXIDE BASED ON DSSC

ASYRAF ARIFFIFUDDIN BIN DAUD

A final year project report submitted in partial fulfilment of
the requirement for the degree of
Bachelor of Engineering (Hons) in Electronics (Telecommunications)

Faculty of Engineering
Universiti Malaysia Sarawak

2019

To my beloved family and friends.

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ABSTRACT

In this study, dye-sensitized solar cells were fabricated using rGO as a semiconducting layer dyed with different natural extracts. Reduced graphene oxide (rGO) solution with different molarities were synthesized by chemical reduction with hydrazine hydrate as a reducing agent. The rGO solution is deposited on glass substrates by using drop casting method. The morphological, optical and electrical properties of rGO thin film were carried out using scanning electron microscopy (SEM), Ultraviolet-Visible spectroscopy (UV-Vis), and current-voltage (I-V) characteristic. The effects of different molarity of rGO solution is studied. The performance of the rGO thin film with different organic dyes were tested for the electrical properties at three different condition which are normal, light and dark condition. The morphological study of rGO shows that the 0.010M of rGO solution is the optimum molarity and has a higher absorbance compare to 0.005M and 0.015M. By analysing different organic dyes with rGO thin films such as turmeric (curcumin), spinach (chlorophyll) and beetroot (anthocyanin), it was noted that the chlorophyll pigments from spinach dye has several absorption peaks in the range of wavelength shows by UV-Vis result. Based on I-V curve results, chlorophyll shows the highest current value flows in the DSSC device which is 9.82 mA compared to anthocyanin (8.94 mA) and curcumin dye (6.93 mA). Chlorophyll pigment shows a good electrical conductivity for the DSSC device which is 0.0300 S/m compare to anthocyanin (0.0250 S/m) and curcumin dye (0.0178 S/m). The different type of organic dye affects the performance of DSSC as the efficiency of chlorophyll is 0.235%, anthocyanin (0.193%) and curcumin (0.133%).

ABSTRAK

Dalam kajian ini, sel-sel solar yang peka terhadap dye telah direka menggunakan rGO sebagai lapisan semikonduktor yang dicelup dengan ekstrak semula jadi yang berlainan. Reduced graphene oxide (rGO) dengan molariti yang berbeza telah disintesis oleh pengurangan kimia dengan hydrazine hydrate sebagai ejen pengurangan. Penyelesaian rGO didepositkan pada substrat kaca dengan menggunakan kaedah pemutus jatuh. Ciri-ciri morfologi, optik dan elektrik filem tipis rGO dilakukan menggunakan mikroskop elektron pengimbasan (SEM), spektroskopi Ultraviolet-Visible (UV-Vis), dan ciri-ciri voltan dan arus (I-V). Kesan molariti berbeza penyelesaian rGO dikaji. Prestasi filem tipis rGO dengan pewarna organik yang berbeza telah diuji untuk sifat elektrik. Ciri-ciri elektrik telah diuji pada tiga keadaan yang berbeza iaitu keadaan normal, ringan dan gelap. Kajian morfologi rGO menunjukkan bahawa penyelesaian 0.010M rGO adalah molariti yang optimum dan mempunyai penyerapan yang lebih tinggi berbanding dengan 0.005M dan 0.015M. Dengan menganalisis pewarna organik yang berbeza dengan filem-filem nipis rGO seperti kunyit (curcumin), bayam (klorofil) dan bit (anthocyanin), diperhatikan bahawa pigmen klorofil dari pewarna bayam mempunyai beberapa puncak penyerapan dalam julat panjang gelombang oleh UV-Vis hasilnya. Berdasarkan hasil kurva I-V, klorofil menunjukkan arus nilai arus tertinggi dalam peranti DSSC yang bersamaan dengan 9.82 mA berbanding anthocyanin (8.94 mA) dan pewarna curcumin (6.93 mA). Pigmen klorofil menunjukkan kekonduksian elektrik yang baik untuk peranti DSSC iaitu 0.0300 S / m berbanding dengan anthocyanin (0.0250 S / m) dan pewarna curcumin (0.0178 S / m). Jenis pewarna organik yang berbeza mempengaruhi prestasi DSSC kerana kecekapan klorofil ialah 0.235%, anthocyanin (0.193%) dan curcumin (0.133%).

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LIST OF SYMBOLS

J_{sc}	-	Short-circuit photocurrent density
J_{oc}	-	Open-circuit photocurrent density
V_{sc}	-	Short-circuit voltage
V_{oc}	-	Open-circuit voltage
V_{max}	-	Maximum voltage
I_{sc}	-	Short-circuit current
I_{oc}	-	Open-circuit current
J_{max}	-	Maximum current density
ls	-	Solar light intensity
η	-	Energy conversion efficiency
$N_{excited}$	-	Excited charge carrier
$M_{incident}$	-	Incident Photon number
Kt	-	Carrier transport rate constant
Kr	-	Recombination rate
ηcol	-	Charge collecting efficiency
e^-	-	Electron charge
eV	-	Electronvolts
nm	-	Nanometer
cm	-	Centimeters
W/mK	-	Thermal Conductivity S.I unit
S/cm	-	Electrical Conductivity S.I unit
W/m^2	-	Irradiance S.I unit
mL	-	Millimeters

ϕinj	-	Quantum yield in electron
k	-	Kilo
g	-	Gram
∅	-	Phi
λ	-	Lambda
°C	-	Degree Celsius
%	-	Percentage

LIST OF ABBREVIATIONS

a-Si	-	Amorphous Silicon
CdTe	-	Cadmium Telluride
CIGS	-	Copper Indium Gallium Selenide
$C_6H_8O_6$	-	Ascorbic Acid
DMF	-	Dimethylformamide
DSSC	-	Dye sensitized solar cell
FF	-	Fill Factor
FTO	-	Fluorine doped Tin Oxide
GO	-	Graphene Oxide
Gr	-	Graphite
GrO	-	Dispersing Graphite Oxide
Hz	-	Hertz
H_2SO_4	-	Hydrochloric Acid
H_3PO_4	-	Phosphoric Acid
H_2O_2	-	Hydrogen Peroxide
H_2SO_4	-	Sulfuric Acid
HNO_3	-	Nitric Acid
I	-	Current
I_2	-	Iodine
I-V	-	Current-Voltage
IPCE	-	Incident Photo-to current Conversion Efficiency
$KClO_3$	-	Potassium Chlorate
$KMnO_4$	-	Potassium Permanganate

$NaBH_4$	-	Sodium Borohydride
Nb_2O_5	-	Niobium Oxide
OH	-	Hydroxy/Hydroxyl group
Os	-	Osmium
Pt	-	Platinum
RPM	-	Revolution Per Minute
Ru	-	Ruthenium
SEM	-	Scanning Electron Microscopy
Si	-	Silicon
TBP	-	4-ter-butylpyridine
TEMPO	-	2,2,6,6-tetramethyl-1-piperidinyloxy
UV-VIS	-	Ultraviolet-Visible
V	-	Voltage
ZnO	-	Zinc Oxide

CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter will explain briefly about the introduction of the recent issue regarding the non-renewable sources. Therefore, the aim and objectives are to overcome the issue that related to nowadays on the energy source crisis. With the objectives mention in this chapter, the scope of this research will help to contribute to the solution of the problem statement.

1.1 Background of Study

In this modern era of technology advancements, energy source has become one of the obligations for human life. The global energy consumption is increasing year by year along with the increase in world population. The increasing in global energy consumption will lead in the high of demands towards natural resources such as coal, petroleum and natural gas. Unfortunately, these natural resources will cost a thousand of years to produce and its cannot be replaced as fast as they are being consumed. Therefore, the reliability on the other sources of energy, which is renewable will also rise. Renewable energy become more interesting for generating clean energy and reducing greenhouse gas emissions. The renewable energy has many advantages such as less polluting, high availability and no fuel supply problems. As a result, renewable energy sources like solar energy which is considered as the brightest candidate to address this problem.

Solar cell technology has warp up into three generations. The first generation of solar cells are depending on a single crystalline semiconductor wafer. The second generation of solar cells are based on inorganic thin film structure which assembly in the

cell. It is uncomplicated and cheaper to produce but due to their hazardous materials and applications are limited. Nowadays, silicon solar cells are one of the most solar cells been manufactured for today technology in the world. There are several types of silicon solar cells which are thin-film solar cell and bulk silicon cell. Thin films with silicon-based solar panels tend to be the most demand by people right now. There are the most common thin films solar panels these days for example Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe) along with Amorphous Silicon (a-Si). The next generation solar cells being expected to amuse this solar technology is dye-sensitized solar cells. Currently, the third-generation solar cells still on the research that can improve into a highly efficient cells and economic that can come up as a new technology to compete with traditional technology in the future.

Dye-sensitized solar cells (DSSC) are the next generation of solar cell which has been implemented by O'Regan and Gratzel in 1991 [1]. Dye-sensitized solar cells or DSSC is using the similar operation of photosynthesis to make electrical energy as an output for the device. This simple assemble of solar cell operate by converting the photon from solar energy into the electrical energy depending on the type of sensitization of dyes, wide bandgap semiconductor material and electrolyte [2],[3]. Therefore, the dye sensitized solar cells have been fully studied by the researcher as a new type of solar cells which is involving the nanocrystalline porous semiconductor that absorbed by the dye solution, a platinum as a counter electrode and an electrolyte that containing the iodide-triiodide ions. DSSC is a technology that associate with the process of the conversion of light energy into electrical energy. This process is based on the type of dye solution that being immersed into the metal oxide semiconductors. This photosensitization is come from the type of dye absorption which it is from the visible light spectrum. The dye solution is performed by absorbing the light source and produce the final product into electrical energy.

The unique process of dye-sensitized solar cells (DSSC) is are one of promising candidates of new technology by reason of they are volatile and inexpensive and this causing them as an ideal for small-scale and large-scale applications. The advantages of DSSC are they can be conduct into low cost of sensitization material production, flexible sheets, low process temperature and ease of fabrication. The flexibility of the dye sensitized solar cell give the convenience which it can be carrying out even can be fold and save more space. Moreover, it can work in cloudy weather or low light condition. DSSC perform better under lower light intensity which makes them an excellent choice